THE 19th CHESAPEAKE SAILING YACHT SYMPOSIUM

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Development and Initial Review of the Mark II Navy 44 Sail Training Craft

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Renaissance, NA21 returning from sea trials. Photo courtesy Jim Mumper

ABSTRACT

Offshore seamanship and navigation training in small sailing craft is a key component in the professional development of many midshipmen at the United States Naval Academy. Spanning six decades, the offshore sail training program uses purpose designed and built craft that occupy a unique niche in the sailing world. This paper details the development and initial feedback from the fourth generation craft. As the paper also includes significant technical design detail, it can also serve as a example of modern cruising yacht design. The paper identifies the major design drivers as well as the key design decisions with the background reasoning and research. Significant technical details of the hull, appendages, deck layout and rigging are presented, along with material selections and quality assurance and control processes. Midstream design changes are explained as well as feedback from the sea trials, delivery and initial racing and sail training use. Finally, the lessons learned from the entire process are presented for consideration.

INTRODUCTION

This paper complements one from the 17th CSYS (Miller, 2003) that presented student research projects related to the development of the new Navy 44. This paper presents the final design and highlights recommendations and lessons learned for future designs. As described in the 2003 paper,

> "The need for a dedicated offshore sail training craft for the Naval Academy's seamanship and navigation program was first proposed by CDR Conolly in the late 1930's. The first design, a 44-foot mahogany yawl designed by Bill Luders resulted in three boats delivered in 1939 and nine more in 1942. After a lengthy service life these were replaced by similar fiberglass versions between 1966 and 1968 (McNitt, 1996). The third generation was developed in the early-80's due to the yawl's excessive maintenance demands and the dissatisfaction with the yawl's performance and comfort compared to modern vessels. The new vessels were developed in response

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to criteria developed by the Navy Sailing staff and members of the Fales Committee. The all-new design was by McCurdy and Rhodes (M&R). As with the earlier boats, the current 44's were heavily used, and by early 1996 discussions were taking place about possible replacements."

After the 1996 discussions, preliminary conceptual design meetings were held by members of the Naval Academy staff and the Fales Committee while budget requests to the Navy were prepared. In 1999 a budget for 24 boats was secured and discussions focused on improvements to systems, arrangements and structures. The plan at the time was to reuse the existing McCurdy and Rhodes design as much of the original tooling (predominantly the hull and deck molds), which the Navy owned and was stored at Pearson, was thought to be in usable condition. In 2001 the decision was made to create a new design and Pedrick Yacht Designs was brought on initially as a consultant and later as the Principal Designer. 9/11 put a hold on the project for a year and a half, during which time it was determined that the tooling could not be used.

A Request for Proposal was distributed by NAVSEA in late 2003. Bids were received in early 2004 and TPI (now Pearson Composites) was awarded the contract during the summer of 2004. The first of the new Navy 44s was delivered to the Naval Academy in September 2007 and arrived via her own bottom in October that year. The last of the new boats is expected in 2010. The project duration from the first meeting through first delivery was eleven years.

The mission criteria for every generation of the 44-foot Sail Training Craft (STC) were (McCurdy and Bonds, 1989):

- Safe for novices
- Low maintenance (high durability in an intensive training environment)
- Offshore capability for trips to Bermuda with a semi-skilled crew of ten
- Favorable treatment under existing rating rules

These general criteria resulted in detailed requirements and specifications for all four designs which were many pages in length. Table 1 from (Miller, 2003) shows the Principal Characteristics of the first three Navy 44s and the target values for the new design. All three earlier designs were well-regarded in their day and admirably served the Naval Academy's mission. At least two of the original boats are still in service, as are nearly all of the fiberglass yawls. The Coast Guard Academy has used four fiberglass yawls in their rigorous program since the 1980's.

	Luders wood	Luders glass	M&R	"Mk 2" preliminary
LOA (ft)	44.0	44.2	43.9	44.0
LWL (ft)	30.0	30.1	34.2	36.8
Beam (ft)	10.6	11.1	12.4	12.4
Draft (ft)	6.00	6.17	7.25	7.42
Disp (lb)	23,400	24,800	28,600	27,700
Sail Area (sq ft)	980	1050	1017	1080
Disp-Length ratio	386.9	406.0	320.3	249.1
SA-Disp ratio	19.1	19.7	17.4	18.8
LPS (deg)	unknown	130	129	130

Table 1: Principal characteristics of the first three generations and target values for the fourth

Drawing on their extensive design knowledge, combined with input from the Naval Academy's sail training staff, faculty and student projects, Pedrick Yacht Designs engineered a boat that met all design criteria.

ACQUISITION STRATEGY AND SPECIFICATIONS DEVELOPMENT

Purchasing anything with government money is a challenge due to the well-known restrictions intended to ensure good value for the taxpayers. While the procurement process is remarkably efficient for items purchased frequently, the system is not streamlined for items purchased infrequently such as sail training craft. Two main factors drive this - the desire for low initial cost and the desire for off-the-shelf components.

The Naval Academy has decades of experience with the purpose-built Navy 44s and various donated racing and cruising boats of similar size. Estimates compiled by the Naval Station staff showed that the higher initial cost of the specialized Navy 44s repaid themselves many times over with significantly lower maintenance and repair costs over their life span, as well as greater durability in extreme conditions and reduced down time, leading to greater utilization factors and lower life-cycle costs. This goal of lower life-cycle cost was a direct result of the anticipated future lower manning anticipated in the maintenance and repair facilities of the Naval Academy. It was, however, a challenge given the purchasing focus on the lowest bidder. The solution centered on whether the Academy should go with a performance specification or detailed specification for the boats.

A detailed specification is essentially a design provided to the bidders. This can be a complete design that includes every aspect of the construction, down to calling out specific building methods and hardware or it can be a less-detailed design where the builder's experience can be used to streamline the construction process. The first is commonly used in the Navy while the second is common in the small craft industry. The other option is a

performance specification where the customer's goals are listed and the bidder determines almost all the details.

The second approach lends itself to include modified off-the-shelf designs to potentially save money. In this case the Naval Academy explored current recreational and charter vessels available on the market and evaluated their potential for modification to sail training craft. While numerous vessels were approximately the same length and beam, none were built with the inherent toughness needed in midshipman sail training craft. The increased weight in the structures and rig would require a decrease in the ballast to allow the vessel to float on its lines, which would then not allow the vessels to pass the stringent stability requirements. After numerous discussions and based on the Academy's success with purpose-built designs, NAVSEA recommended proceeding with a detailed design approach.

While the decision on which technical approach to take was ongoing, the funding side also progressed. Normally vessels are purchased with "Shipbuilding and Conversion, Navy Appropriation" (SCN) funds allocated by Congress. The downside to these funds is that they can be reallocated to other projects relatively easily. The Naval Academy, fearing that sail training craft would be easily bumped, chose to fund the STC through Educational Support Equipment (ESE) funding. That funding is provided by Congress with limited detailing and can be reallocated at the Naval Academy level as needed. The downside to ESE funds is that it is anticipated that costs will not rise for the fixed-price contracts, which are typically short term contracts of relatively low value. SCN funds are longer-term contracts where cost growth due to changing conditions is expected. SCN funds are "owned" by NAVSEA, while the ESE funds were USNA money. This clouded the ownership issue as NAVSEA was tasked to manage someone else's money, something they were not accustomed to. This caused a few tense moments when NAVSEA wanted to head in a direction the Naval Academy did not.

Specifications and Copyright

Development of the Specifications began with RADM McNitt's questionnaire of January 1996 investigating potential improvements to the McCurdy and Rhodes Navy 44. The report issued in September 1996 had 35 specific recommendations, including a redesigned cockpit, new rudder design, new engine and systems and improved chainplate design. It also recommended retaining the standard criteria for Navy Offshore Sail Training Craft, including the stringent stability and construction standards. Recommendation #1 was to reuse the existing M&R design.

The Configuration Control Committee (CCC) continued to develop the detailed specifications for all parts of the design over the next three years. With the development of the IMS rule and advanced computer modeling, the late 90's saw a significant improvement in the understanding of sail boat design. This, combined with the loss of tooling for the M&R Navy 44 and the difficulty of incorporating numerous changes in an existing design, led the Superintendent to decide in May 2001 to develop a new design. This expanded the specifications to over 30 pages (PEO 2004).

With the decision to develop a new design came the question of how much of the M&R design to maintain in the new design. As noted above the design features were well regarded and were desired in the new design. The question of intellectual property (IP) then arose. While significant input from the Naval Academy was provided to M&R, the design was paid for and owned by the Fales Committee, which licensed the Navy to build the boats. This created a gray area in IP which was resolved by a review by the Naval Station's JAG officer. Their review pointed out that vessel designs, unlike other copyrights, were covered by the Hull Design Protection Act which limited protection to only ten years. As the M&R design was then twenty years old, no conflict was seen. Nonetheless, they also recommended using only the broad guidelines of the design criteria and not specific design information from the older design. The new design would be paid for by Navy funds and owned by the Navy, with the designer licensed to develop the design for non-governmental purposes.

The styling of the M&R Navy 44 was recognized by many as sort of an unofficial trademark of Navy Sailing and was captured on a 1995 postage stamp commemorating the Academy's 150th birthday. The Director of Naval Academy Sailing (DNAS), wishing to recognize the stature of the M&R design, instructed the 4th generation design to be called the "Mk II Navy 44" and directed the CCC to create a design that looked substantially like the one pictured on the stamp. As an engineering constraint that definition was difficult to interpret and a follow-on instruction led to the agreement that keeping most visual dimensional changes to approximately four inches would be acceptable.

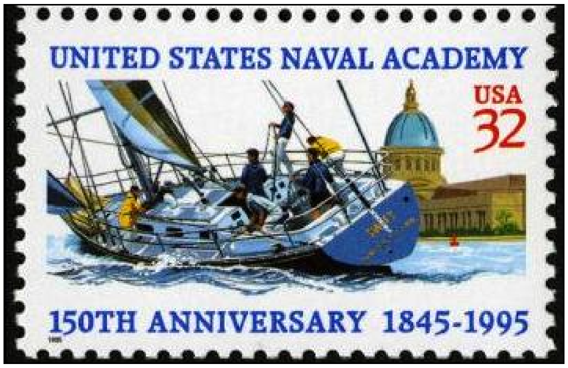

Figure 2: Commemorative Stamp showing the M&R Navy 44

The final design criteria included the general criteria listed above, the aesthetic criteria from DNAS and standardized criteria included in the specifications. The latter included applicable federal, commercial and sailing standards:

- U.S. Coast Guard Navigation Rules which implements the International Regulations for Prevention of Collisions at Sea, 1972 (COLREGS), including the 1989 amendments
- U. S. Coast Guard Safety Standards, Instructions, and Regulations
- American Bureau of Shipping Guide for Building and Classing Offshore Racing Yachts, 1994
- American Boat and Yacht Council (ABYC) Standards and Technical Information Reports
- The International Sailing Federation (ISAF) Special Regulations for Yachts in Category One
- Fire Protection Standard for Motor Craft NFPA number 302
- American Society of Testing of Materials (ASTM) tests and material specifications for the materials used in construction
- Colors Used in Government Procurement, FED-STD-595B

The final dimensional specifications are shown as the first six rows of Table 2 (see page 9) for overall and waterline length, beam, draft, sail area, and displacement. Also called out in the specifications was an air draft of 65 feet for the standard minimum bridge clearance on the ICW. Not called out in the detailed specification was a specific stability value, the absence of which was to become a costly error.

Throughout the design process the CCC maintained that the stability of the new boat should be at least as high as the M&R design. A review of the IMS certificates indicated a minimum value of 127 degrees Limit of Positive Stability (LPS). This became a design goal of 125 degrees, which although was included in numerous correspondence was omitted from the design specifications. The reasoning was that as the design was a detailed design, the LPS was indirectly imbedded in the design and was therefore already "captured" by the design details.

An additional error in the specifications development surfaced during the initial construction phase. The responsibility for developing the specifications, which took highest precedence in the contract, was NAVSEA's. As they were unfamiliar with sailing craft they relied on the Naval Academy for much of the details and as NAVSEA was short of personnel they tasked a contractor, CSC, to write the specs. Concurrently, Pedrick Yacht Designs was contracted to develop drawings from the Specifications and was given a firm deadline by NAVSEA. Unfortunately, CSC/NAVSEA/USNA completed the specifications nearly six months after the drawings were completed. This resulted in numerous conflicts, redesigns and change orders.

DESIGN OVERVIEW

Design Brief by the Client

Pedrick Yacht Designs was first contacted about the possibility of designing the new Navy 44 Sail Training Craft (STC's) early in 2001. Because the new craft's planning had been under way for awhile, some well established ideas were already in place among the various stakeholders. It was quickly apparent that they were not all coming from the same song sheet. The early challenge of the design was to understand the fundamental requirements of the craft's mission, the reasons why there was a high level of satisfaction with the existing MK I craft, the value of making some worthwhile improvements, and the roles of various opinionated parties.

The persons in charge of the Naval Academy's sail training program realized that, even as stoutly built craft, hard use in an active training program would give their existing MK I STC's a practical service life of twenty years or less. They are in active service about 250 days per year. Eventually, the annual cost of repairs and replacement of equipment, together with associated down time, would become substantial. Academy personnel responsible for the STC's realized that they had to start the fleet replacement process early, because it would take at least five years to go through the design and construction program, allowing for the federal procurement process. They were optimists.

Although the NA44 MK I sail training craft had an attractive, cruiser-racer style, it was made clear from the start that these were not yachts. They were first and foremost work boats for teaching seamanship and teamwork to midshipmen beginning at the novice level. Only four of the fleet of twenty MK I craft were used by the Varsity Offshore Racing Team, distinguished primarily by fitting them with headfoils for their jibs instead of

hanks. Like the MK I's, the replacement craft were to be constructed and outfitted to an industrial level to fulfill their role as training vessels of the U.S. Navy for the development of future officers. Still, there was a soft spot for how the MK I's looked, and the MK II was required to look essentially the same at first glance. Figure 3 shows that was achieved.

Figure 3: NA44 STC Mk II on the left, Mk I on the right
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Generally, the MK II version of the NA44 sail training craft (STC) was to incorporate the large majority of features that had been decided for the MK I craft in the 1980's. (McCurdy and Bonds, 1989) The MK I resulted from rigorous consideration of the sail training mission, the number of midshipmen per craft, the most suitable craft size, features to support those requirements, and other desirable characteristics that would make them good boats for their purpose. In preliminary discussions with Academy staff, it was clear that the MK I STC provided a worthy baseline from which to create the next generation 44. Nevertheless, in the roughly fifteen years since the design decisions were made for the MK I, there had been genuine advances in hydrodynamic and structural design, as well in equipment and details of layout, that would permit creating a superior MK II craft.

Where to Begin?

For Pedrick Yacht Designs (PYD), the project started right off with a number of new experiences. One was "Meet the Clients" day in early October, 2001, following a period of preliminary planning and development with the Academy's sail training staff.

This first full, official design meeting was at Naval Station Annapolis a few weeks after 9/11. It started by learning what DefCon 3 meant. At least, upon presentation of the visiting pass and identification at the jersey barriers when entering the base, the guards' guns were just at the ready, instead of being aimed to shoot as they would have been a week or two earlier.

Then began the challenge of sorting out who was who among the various stakeholders. Overall coordination and operation of the sail training programs for the Academy is assigned to the Director, Naval Academy Sailing (DNAS), who reports to the Academy's Superintendent. DNAS was the Commanding Officer, Naval Station Annapolis (now Naval Support Activity – Annapolis), which, among other things, operates a supporting shipyard facility on the Severn River opposite the Academy. Because this is where the Academy's training craft are maintained, the veteran manager of the shipyard was especially valuable in furnishing practical input.

Pedrick Yacht Designs' main contact for the start-up of the Mark II design program had been the sail training program's Vanderstar Chair Ralph Naranjo. The Vanderstar Chair is DNAS's senior boatshoes-on-the-dock director and advisor for all training issues of the midshipmen, as well as for the material condition of the training craft. Mr. Naranjo brought his exceptional knowledge of boat building and equipment to that position. Naval architecture professor Paul Miller had also been involved throughout years of study toward the development of the MK II replacement craft, including related design and structural projects by midshipmen.

Then, there was the Fales Committee, an advisory body of experienced mariners reporting to the Superintendent on the Academy's sailing programs, including the seaworthiness and safety of its sail training craft and the adequacy of the sail training program. It also provides specialized information to the Superintendent on subjects for which members have particular expertise. Accordingly, the Fales Committee had appointed a Configuration Control Committee (CCC), which had been granted substantial authority over design features for the new NA44 STC MK II.

As Naval vessels, though, the crafts' real buyer was NAVSEA, the Naval Sea Systems Command, through its Combatant Craft Department (CCD) in Norfolk, VA. Being an organization that's more familiar with SEAL boats than sailboats, it relied heavily on the direction that it received from Naval Academy personnel, although it was not answerable to them. Fortunately, the NAVSEA coordinator during the initial design stage was an experienced sailor

who helped facilitate the elements of the project to meet NAVSEA's standards and practices. Finally, the government contracting entity for the preliminary design was a third-party Washington Beltway engineering company.

If this appears to be a multi-headed Hydra, it was. Pedrick Yacht Designs, engaged as the key creative contractor, made its design recommendations in the best way that it could while sorting out who, among Hydra's heads, was really the firm's client. With lengthy diplomacy and the occasional hierarchical hammer among the Navy folks, PYD eventually introduced worthwhile improvements into the MK II design while achieving some concessions from risk-averse conservatives who maintained that, even though a change is technically sound, it is not necessarily desirable.

Initial Summary of Principal Design Objectives

From initial design discussions, Pedrick Yacht Designs produced a summary of the client's objectives for the MK II sail training craft prior to the "Meet the Clients" meeting. These objectives were maintained throughout the project.

Features to be maintained:

- Existing midshipmen seamanship training mission
- Existing aesthetic appearance
- Majority of existing deck and interior arrangement
- Existing mast and rigging configuration
- Existing fore triangle and headsails
- Existing systems by type, to be updated as directed

Features to be improved:

- Construction materials, scantlings and processes
- Cockpit layout –
  - Traveler and mainsheet location
  - Liferaft type, stowage and deployment
  - Cockpit footwell length and cabin access
- Details of deck hardware, hatches and ventilation
- Boom length and mainsail foot to suit new mainsheet location
- Interior layout –
  - Dedicated wet locker for lines and foul weather gear
  - Head relocated forward of mast, minor adjustments to suit
  - Provision for trash to be improved
- Machinery –
  - New make of main engine
- Systems –
  - General improvements to be directed by NAVSEA
  - Increased holding tank capacity
- Appendages –
  - Keel design having lower center of gravity
  - Spade rudder for more effective maneuvering and control
- Reduced weight by savings in construction and ballast
- Increased stability by lower center of gravity
- Improved performance by subtle increases in –
  - Length
  - Stability
  - Sail area
  - Appendage hydrodynamics
  - Reduction in displacement
- Improved handling by –
  - Increased stability for responding to gusts
  - Reduced wheel load by balanced rudder blade
  - More rapid steering response by spade rudder type

Recognizing that the starting point was based on generally satisfactory service experience with the MK I's, it made sense to preserve many features of the existing craft, while having good reason to incorporate sensible improvements. The MK I's size and general arrangement worked well, although experience had suggested that relocating the head forward would open up useful wet locker and stowage space aft. This was accommodated by subtle changes in hull and deck configuration. Of course, it had to be a 44, but length was stretched slightly to 44 ft 4 in.

The waterline was lengthened by using the maximum permitted steepening of the stem rake and lowering of the counter. Effective sailing length was increased further by broadening the lines aft within permitted limits of change. Stability was improved by an increase in waterline beam and a lower VCG, while targeting a modest reduction in displacement. The cumulative changes in length and displacement gave the MK II design a much lower displacement-length ratio than the MK I, which would contribute to better seakindliness as well as to improved performance.

The MK II's rig had to be interchangeable with the MK I. This would facilitate the gradual changeover of the fleet. Also, while the eventual disposition of the MK I fleet wasn't determined, it was desired to maintain service capability for the MK II's that would be consistent with the MK I's. The mast height, standing rigging and fore triangle base had to be identical between the MK I and MK II. However, PYD wanted to add mainsail area and relocate the main traveler through a longer boom, which the client team accepted.

The deck plan was arranged to promote teamwork. Contrary to the general trend of consolidating various sail controls onto fewer winches, the NA 44 spreads jobs out

for the eight-person crew to all participate. Accordingly, the cockpit and cabin house were set up to distribute crew work productively.

The Naval Academy faculty and students had progressed on new scantlings that would benefit from structural efficiency and laminate quality of new fiberglass materials, resins and manufacturing processes. Impact strength was analyzed, in particular. It was initially believed that these improvements would permit some lightening of construction weight while also increasing strength. Whether as novices or hot-dogs, the midshipmen manage to hit docks, rocks and each other with the NA44's, and they have to resist such punishment much more successfully than boats built for the consumer or charter markets.

Creating secure and forgiving handling takes a combination of art, science and experience by the naval architect. Pedrick Yacht Designs approached its design choices for the keel, rudder, sail plan and stability so that the MK II would be very tolerant of both momentary gusts and storm conditions with confident steering control and a light touch on the helm. These goals were achieved.

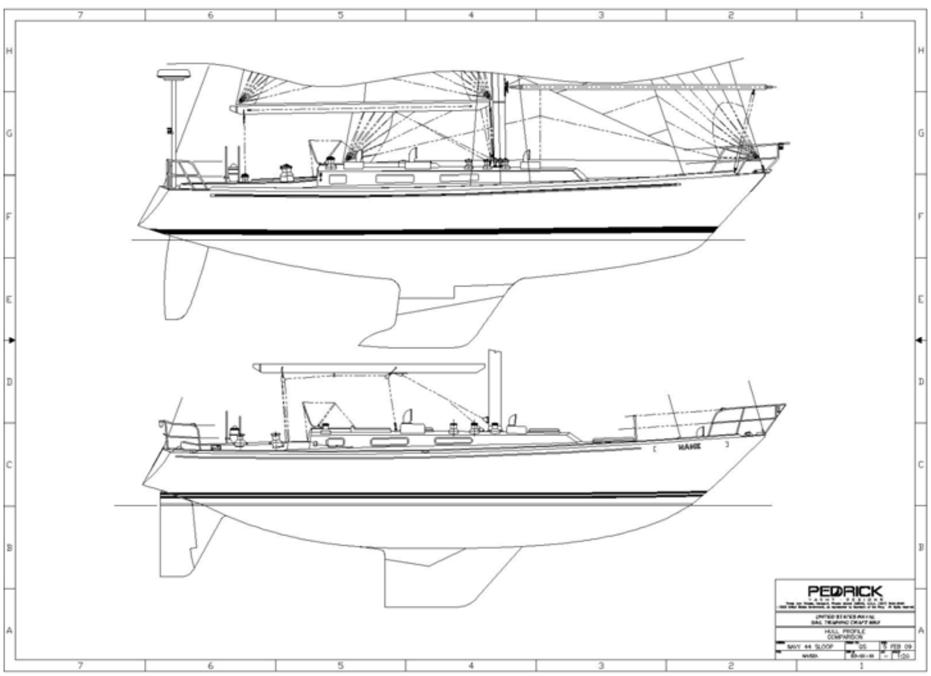

Figure 4: PYD NA44 STC MK II above, M&R NA44 below

The qualities of the Navy 44 are consistent with an exceptionally comfortable, fast, seaworthy cruising yacht. The attractive, well-proportioned hull is of moderate displacement, having substantial payload, stability and a seakindly form. To suit normal consumer preferences, the interior can be adapted for the comforts of a smaller complement. Structurally, the hull and appendages are unusually robust. And, handling is very gentle, whether by helmsman's touch or by autopilot. Virtually all of the key features that make the NA44 STC MK II good for the midshipmen make it a good craft, as well, for personal cruising.

Going from Design to Construction

The MK II design was substantially defined within the first few months, prior to the end of 2001. It then went dormant throughout 2002 due to defense priorities for the war on terror in Afghanistan. It was restored in the 2003 budget, but funding and direction for the design weren't re-started until spring. Even then, the responsible officer at NAVSEA was given a very short leash on how much time he could give to the project. Full details of the design, described later in this paper, were developed, drawn, specified and ready for final review by the end of 2003. The Final Design Package was published on "fedbizopps.gov" in March 2004 to invite bidding for construction.

That led to an astonishing lesson about how government contracting can work. The procurement of the craft was through NAVSEA's Beltway contracting bureaucracy. The business details between NAVSEA and the selected builder didn't concern Pedrick Yacht Designs for the most part, although one perplexing issue stood out.

It has always been normal and beneficial to Pedrick Yacht Designs' clients for the firm to be actively engaged with the builder throughout construction, helping to resolve questions or problems as they arise. It would have been especially easy to have maintained frequent face-to-face support to the builder in this case, as PYD was just 40 minutes away. Open and active channels of communication between the designer and the builder typically facilitate a smoother and more satisfactory completion of the project. The Naval Academy personnel, right up to the Superintendent, wanted it that way.

NAVSEA contracting saw it differently. They seemed to fear that direct discussions between the designer and builder would invoke cost extras and delays, rather than facilitate smooth execution of work. For more than a year,

neither the logic of Pedrick Yacht Designs' appeals nor the persuasion of the Naval Academy could overcome the fears of NAVSEA contracting. In the end, the bureaucrats held superior firepower. They won the battle, but it will be seen that they lost the war. Eventual delays and added costs of this project were undoubtedly greater than if the builder and designer had been allowed to work together. It took three years to go from the supply of the hull's CAD lofting to sea trials of the first hull – about three times as long as in a normal production boat project.

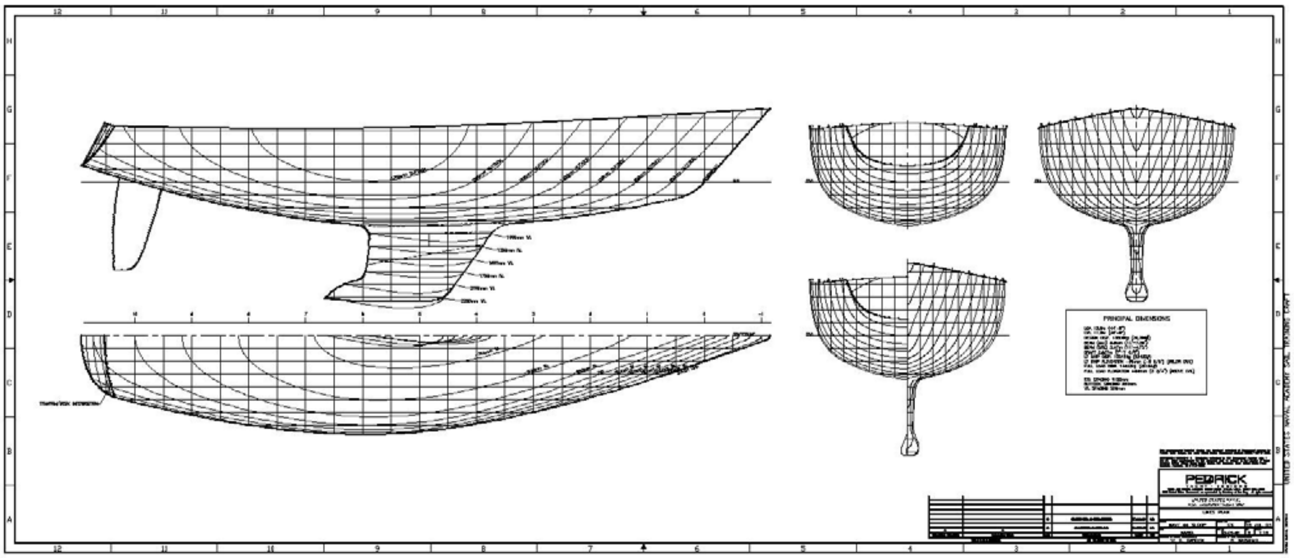

Figure 5: Navy 44 Mk 2 Lines Plan

CCD provided on-site supervision of the project – occasional at first and then through a staff naval architect who was substantially resident at the factory for two years. There were particular issues for which Pedrick Yacht Designs was brought in by NAVSEA, but, overall, it proved to be a clumsy, costly , time-consuming, frustrating, yet ultimately successful way to build small craft.

The project did benefit from a strong quality assurance program. Extensive controls over thoroughly specified standards of construction were enforced rigorously. Nothing went unchecked in the production of the first craft and the start of the next few. Of course, reports were up to the levels that the government is good at generating. Upon completion of comprehensive systems testing and sea trials of "Renaissance," the first hull, the success of the MK II's design and execution was proven, leaving nothing substantial on the punch list by the time she left Rhode Island waters for Annapolis.

DESIGN DESCRIPTION

The contract design package submitted to TPI (now Pearson Composites) consisted of 31 separate drawings and four 3D IGES files giving the lofted shapes of the hull, keel, rudder, and deck. Along with the normal design drawings including lines, arrangement, deck plan, sail plan, and hull and deck construction, detailed drawings such as a bonding and grounding diagram, Treadmaster non-skid layout and many others were included in the comprehensive design package.

Lines

The Hull Lines show a traditional-looking profile and stem rake with somewhat V'd sections forward to avoid pounding in a seaway. The after sections are more U'd, providing a fairly flat and powerful counter. While far from the boxy after sections that are popular today in grand-prix race boats, the MK II's wide, flat after sections allow the boat to surf more easily while still remaining sea-kindly and giving a more traditional appearance. The keel lines are also shown with a forgiving, low-VCG, long-chord keel with integral keel sump. The large spade rudder is shown in profile only.

Principal Characteristics

The Principal Characteristics for the vessel as well as Characteristics at Measurement Trim are listed in Tables 2 & 3

Compared to the M&R 44's, the MK II is about 3/4 ton lighter, primarily in ballast weight due to the more effective keel shape and slightly increased draft. The prismatic coefficient was reduced through a longer waterline, lower displacement and wider beam at waterline. The displacement length ratio was also reduced, providing a more easily driven hull.

	Table 2	
Principal Characteristics		
Navy 44 STC Mk II		
LOA	44'-6"	(13.56m)
DWL	36'-9"	(11.20m)
DWL Displacement	30,400#	(13800kg)
Beam (Max)	12'-7 1/4"	(3.84m)
Beam (DWL)	11'-4 3/4"	(3.45m)
Draft (DWL)	7'-7 5/8"	(2.33m)

	Table 3	
Characteristics at Measurement Trim		
Navy 44 STC Mk II		
Displacement	26,800#	(12,200kg)
Ballast	9,900#	(4,500kg)
Wetted Area	405 ft^2	(37.6m^2)
Draft	7'-5 3/8"	(2.28m)
VCB (Below DWL)	1'-4"	(0.41m)
LCB (LCB/LWL)	0.539	
LCF (LCF/LWL)	0.560	
MT (Above DWL)	3'-4 1/8"	(1.020m)
RM 1 deg	1870 ft-lbs	(259 kg-m)
Pounds per Inch Immersion	1,461 lbs/in	
MCTI	2,664 ft-lbs/in	
Cp	0.540	
Disp-Length Ratio	228.0	

Sail Plan

Sail plan development was restricted by the desire to use the same rig layout and mast section as the M&R 44's, which had proven to be very robust, even when striking a bridge. A related requirement was that the mast height was limited to the 65' vertical clearance of bridges on the Intra-Coastal Waterway. Further, the Academy wanted the headsails to be interchangeable between generations to allow sails from the Mk II fleet to be passed down to the Mk I boats, which may be distributed to sailing programs at various Naval bases around the country once the new fleet is delivered. By increasing the length of the boom, sail area was added and the mainsheet traveler was moved aft to just in front of the helm. (On the MK I, it was located on a large bridge deck just aft of the companionway.)

General Arrangement

The Academy was generally happy with the arrangement of the existing fleet, but had a few desires. They wanted a large wet-locker and changing area immediately adjacent to the companionway to allow midshipmen to remove their foulies without tracking water around the cabin. The wet-locker was located where the head was previously located, to port of the companionway which also allowed enlarging the hanging locker just forward of it. This also allowed the large sail locker to be located under the port cockpit seat.

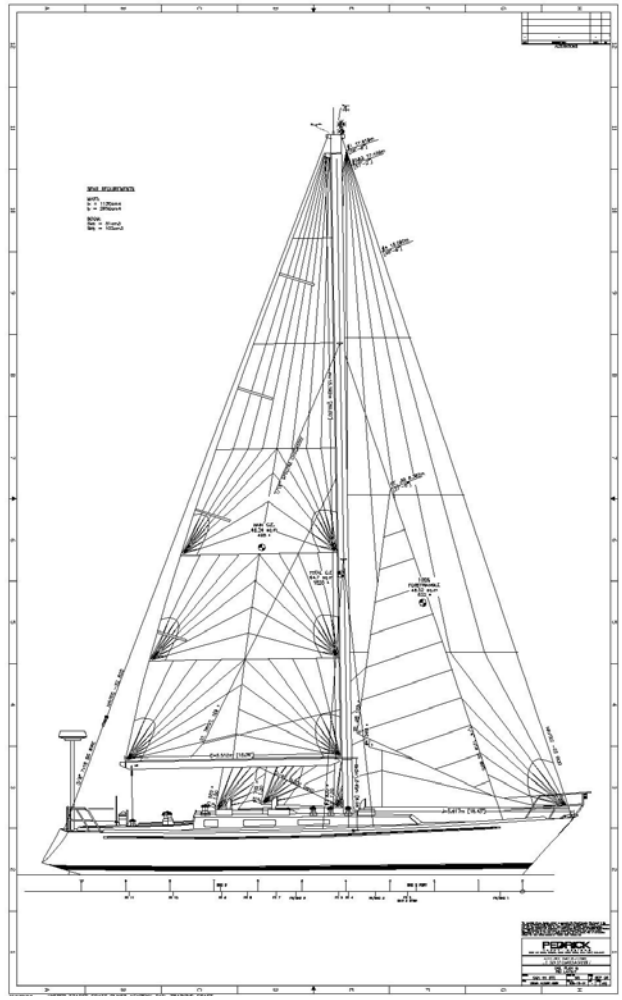

Figure 6: Navy 44 Mk 2 Sail Plan

An extra-large Nav station for midshipmen instruction was maintained, while upgrading it to modern navigational methods with a sliding laptop drawer and LCD multi-function display. It also provides a large table for paper charts. Ample battery storage was incorporated under the Nav seat. The Academy liked the open galley of the MK I, but desired more security for the cook, which was accomplished with a removable sea rail. This turns the "L-galley" into a "U-galley" while still maintaining an open feel.

A single berth for the Officer in Charge (OIC) was located aft of the galley in a similar manner to the previous craft, but the wider beam aft allowed this berth to be improved. The salon's 4-berth settee arrangement with removable table was maintained, but the pilot berths were much improved due to the slightly wider local beam and the use of composite chainplates to minimize berth intrusion. The composite chainplates also prevented deck leaks, a troublesome problem on the MK I's.

With the wet-locker aft, the head was moved forward of the mast to starboard, replacing the previous hanging locker. Great care was taken to provide enough room for the door to swing inward and still operate, but during construction, this detail was changed to allow the head door to double as a privacy divider for the forward cabin. A shelved locker to port provides spares storage, and 4 pipe-berths forward are similar to the MK I design.

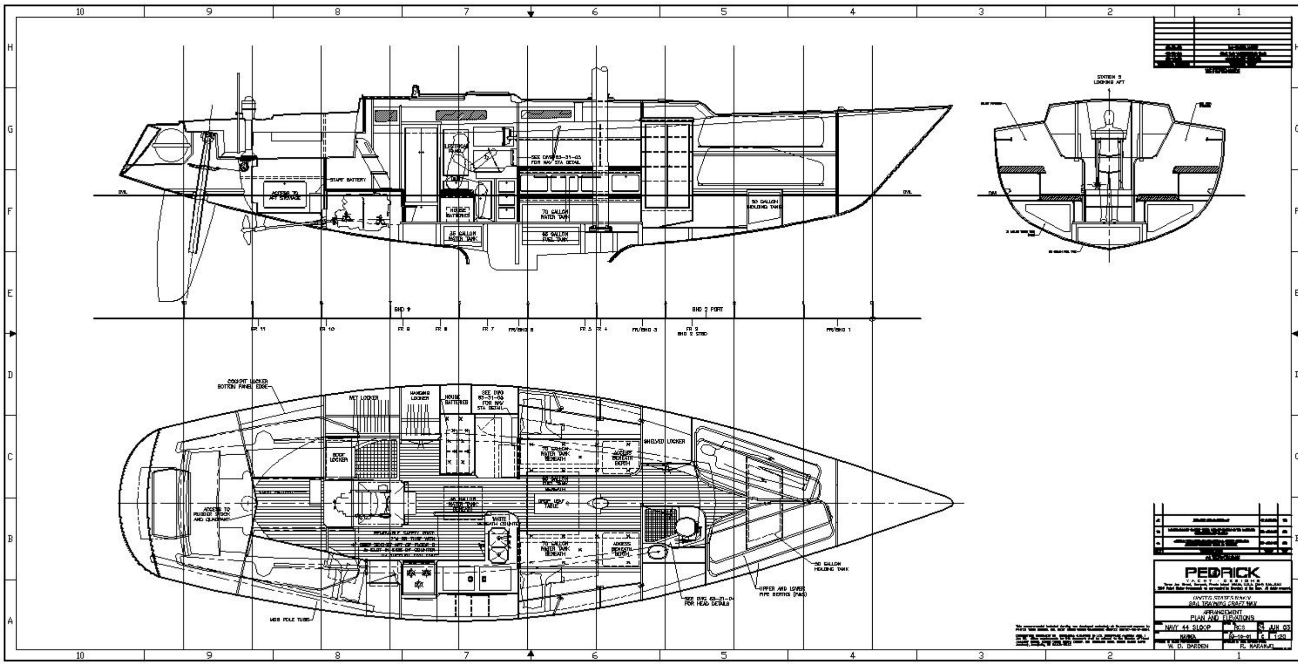

Figure 7: General Arrangement

The primary water tanks are under the salon settees. The hull design accommodates a generous fuel tank and a third water tank under the sole, impossible in typical, modern, shallow bilged modern boats. An under-sole water tank aft simplifies the water system by allowing the wing tanks to gravity feed the central tank, which has the fresh water pump pickup. An extra large (50 gal) holding tank was located forward under the pipe berths, and doubles as a storage divider. A watertight collision bulkhead with a robust aluminum access hatch was included to improve survivability of the boat should it strike another vessel or floating object. The arrangement plan also shows the integral aft liferaft locker, which will be discussed in greater detail later.

Deck Plan

The deck plan and cockpit arrangement were areas of much discussion and development by the design team and the Naval Academy. The MK I arrangement featured a bridge deck, supporting the traveler aft of the companionway and housing a hard canister liferaft which then had to be lifted out of the cockpit to deploy. The traveler location forced those going below or coming up on deck to pass over the traveler – a clumsy and dangerous operation. The mainsheet winch was located on the cabin-top, which placed mainsheet and jib trimmers in essentially the same location and limited the mainsheet trimmer's sightlines on one tack. The design goals for the new cockpit were to move the traveler away from the companionway, remove the clumsy bridge deck, increase available cockpit space, move the liferaft to a readily deployable location and improve cockpit ergonomics for the trimmers.

The solution was to locate the traveler just in front of the pedestal. Dual mainsheet winches outboard of the traveler allow mainsail trim to be controlled from the weather side on both tacks, increasing visibility for the main trimmer. It also places the main trimmer right next to the helmsman, improving communication. With the helmsman and main trimmer sitting to weather on the cockpit coaming, the winch is located just aft of the trimmer with traveler controls between his legs, allowing good leverage. This allows the jib trimmer and grinder plenty of space to leeward around the large primary winches. Spinnaker sheets are led to the cabin-top secondary winches with the afterguy going to the unused windward primary. This more modern cockpit arrangement improves ergonomics and communication and reduces situations where two or more people have to occupy the same space to do their job. It also opened up the cockpit for improved casual use. Eight crew can sit comfortably in the MK II's cockpit while sailing, an impossibility in the MK I.

The liferaft was located in an integral transom locker with a

protective cover that completes the transom and after deck. One motion releases the hatch cover, which may then be cast off the stern (attached by a lanyard and specified to float). A second motion releases the liferaft securing straps and rolls the raft off the stern. The entire procedure can be accomplished easily by a single crew member in under 6 seconds, a dramatic improvement to the previous arrangement where strong crewmembers had to release the raft, slide it aft from under the bridge deck, and then lift it from the cockpit sole over the lifelines. With the weight of modern SOLAS-approved 10-man rafts, this was extremely difficult.

down the hatch in a seaway. In addition, if the spinnaker pole was lowered to the deck while the hatch was open the hatch could not be closed. There were at least two occasions when significant amounts of water went below when waves washed over the foredeck. The new hatch was designed with large gutters to drain moderate amounts of water away even without dogging the hatch, but for really foul weather, the hatch seals tight.

A further significant design detail was the inclusion of a heavy duty, removable bow anchor roller. Being able to remove the roller was important to reduce collision damage when racing, while facilitating anchor handling in normal operation.

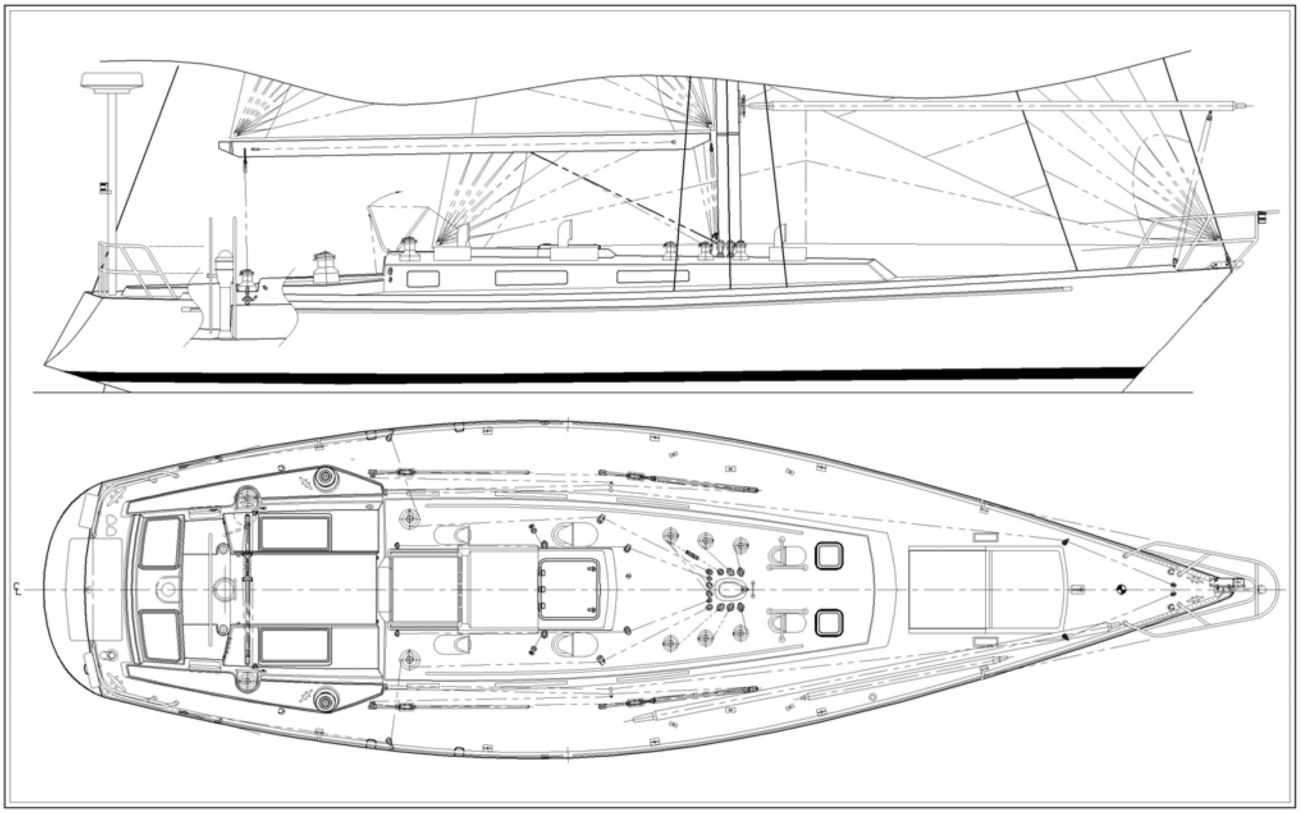

Figure 8: Deck Plan

Amidships, the MK II's deck arrangement remained largely similar to the MK I, with 6 mast winches, providing work stations for the large crew and eliminating multiple rope clutches. Large dorades and cowls provide ventilation even in inclement weather.

An integral fiberglass sliding foredeck hatch was developed based on PYD's design of a foredeck hatch originally for the Maxi racer Nirvana. The MK I's large hinged foredeck hatch was a constant maintenance problem, as the hatch hinge pins would occasionally break if the hatch was stepped on while open. This was sometimes difficult to avoid when stuffing a spinnaker

Based on the Academy's experience with undersized hardware on donated boats, all hardware on the MK II was rather significantly oversized. The primary and other winches are clearly oversized, but experience in repairing and maintaining the heavily used fleet (250+ days a year) had taught the Academy that, by investing in oversized hardware, they could dramatically reduce their maintenance budgets and save significant money over the life of the vessels. Similarly, the oversized extruded aluminum toerail that was used for the Mk I boats was copied because the repair staff reported it had saved thousands of dollars in repairs from collisions. Aside from

that, it provides very secure footing for the sailors onboard, and nearly unlimited connection-points for hardware. A large painted PVC rubrail was added to the boat, capped with a stainless steel rub strake, to reduce topsides paint damage when docking against piers or when coming into their permanent slips which have pilings.

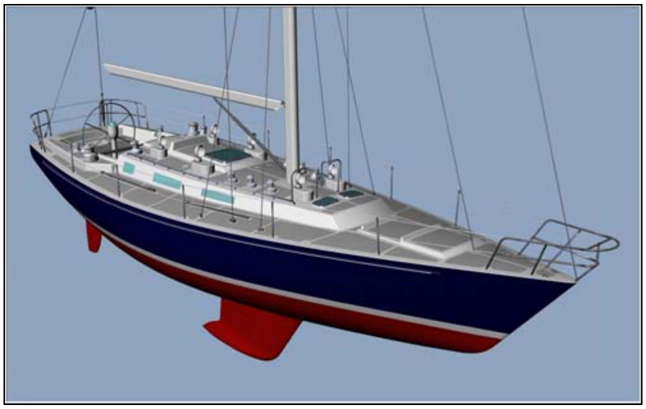

Figure 9: Perspective showing deck plan

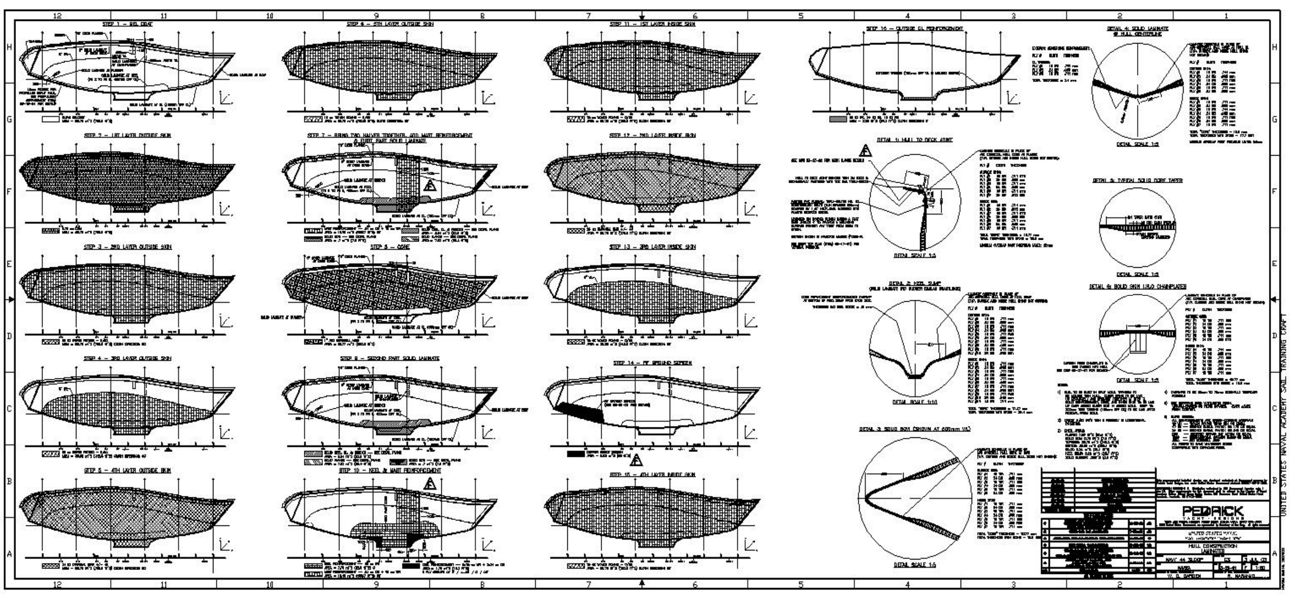

Figure 10: Hull laminate

Structural Design

The Navy 44 STC Mk II general structural design basis was engineered to exceed ABS's requirements . What truly separates these vessel's construction from standard vessels is the details. Every structural detail – especially the keel sump, centerline reinforcement, hull-to-deck joint and hardware attachment – was designed with longevity, damage minimization and ease of repair in mind. Furthermore, specified equipment and materials were kept to the fewest possible to reduce stocking needs for anticipated repairs.

The general laminate was designed after extensive impact testing by Academy students and faculty. The goal was to have the greatest damage resistance while also being the easiest to repair. The Derakane 8084 vinyl ester resin was chosen for its excellent damage resistance due to its high elongation, approaching those of epoxy resins without the need to re-train repair staff to work with a new type of resin. The basic laminate of alternating layers of 17oz stitched +/- 45 deg bias layers with 18oz 0/90 deg woven rovings proved to be more resistant to impact damage than other laminate stacks, and the ATC A600 Corecell was selected for its high elasticity and damage resistance compared to other core materials. A molded floor grid incorporated carbon fiber unidirectional caps reduce weight and increase stiffness. An integral carbon fiber deck beam maximized headroom under the main ring frame between the galley/nav area and the salon. The underside of the cabin house was exposed, giving ready access to deck-mounted hardware without a headliner. G-10 fiberglass core replacement inserts were used at through hulls and in way of deck hardware to eliminate core moisture problems, and additional reinforcements were used liberally at the often-damaged bow and sheer regions.

The basic hull laminate consists of a ¾ oz Chopped Strand Mat (CSM) to support clear gelcoat and provide print-through protection. Clear gelcoat was specified to permit visual inspection of the hull skin laminates from both inside and out. The outside skin consists of a ply of 18oz Woven Roving (WR) followed by a ply of 17oz Double Bias (DB) followed by an 18oz WR, with an extra WR

below the waterline. 1” thick ATC A600 Corecell core is then laid in with conservative 5:1 ratio bevels. The inside skin mirrors the outside skin, but without the CSM. Where the core is removed on centerline forward, in way of the keel sump and at the sheer line, alternating plies of WR & DB replace the core. The keel area is a solid laminate.

The basic deck laminate is similar to the topsides laminate except it has a ¾” A600 core with G-10 core replacement in way of highly loaded deck gear and denser A800 Corecell in way of the mast and chainplate region. Added reinforcements are added to corners, and the sheer and foredeck hatch area are solid skin with added reinforcements replacing the core. The deck uses grey gelcoat to avoid costly deck paint work. The finished deck is then largely covered in Treadmaster non-skid panels, which the Academy has found to be a very long lasting product with superior grip.

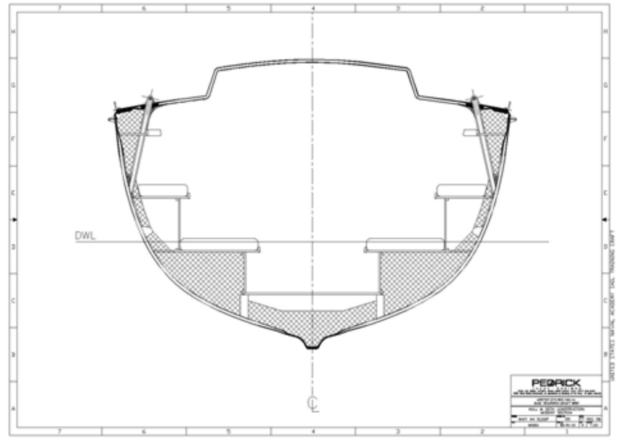

Figure 12: Midships Section

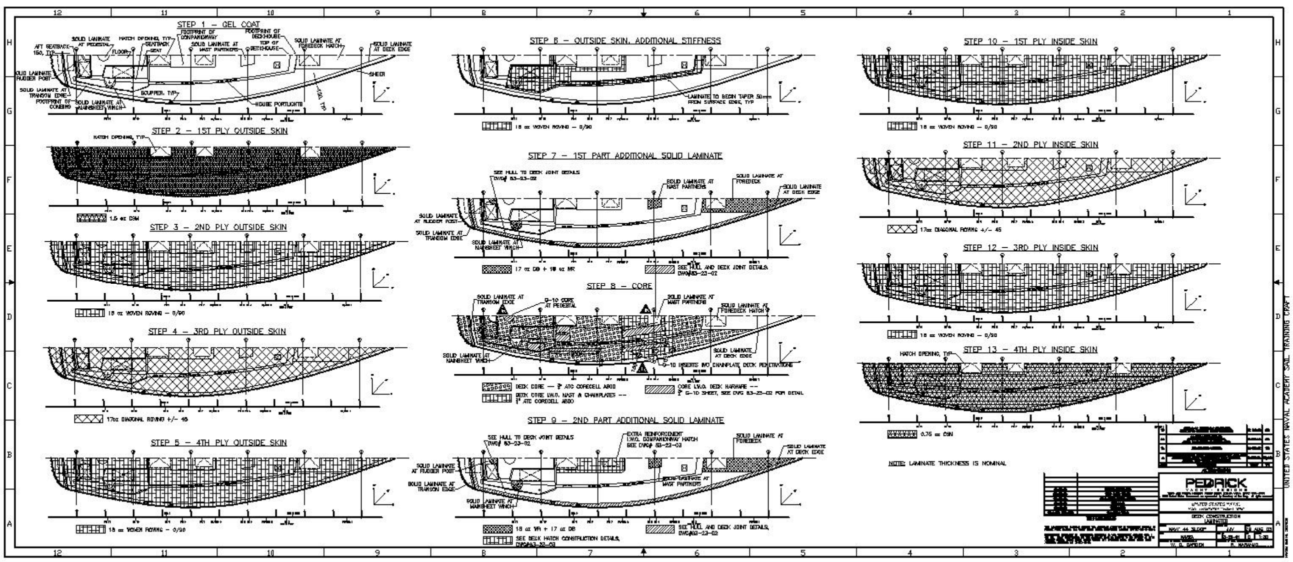

Figure 11: Deck laminate showing reinforcements

Figure 12 is a midships section showing the solid keel sump region and the laminated carbon composite chainplates. The chainplates were designed to be built on a bench by a highly skilled sub-contractor (same supplier as for the rudders) with thick carbon pre-preg laminations in which avoiding any creases or wrinkles is critical to the overall strength. The pre-built chainplates can then be tabbed into the hull and deck, using conservatively engineered tabbing. In addition to being leak free, the carbon chainplates’ intrusion into the pilot-berths was minimized. They were contoured to be more comfortable for midshipmen sleeping offshore than the stainless steel chainplates of the MK I’s.

Stability

The safety and security of students is of the utmost concern for a training craft. As the midshipmen heading offshore often have less than a week of prior training in the 44’s, the Academy was committed to significantly exceeding offshore racing stability requirements. This additional stability had proven to be worthwhile in the MK I STC’s.

Excessive as-built weight of the first hull caught everyone by surprise. It was approximately 1800 pounds higher than expected. While the reasons for this were being investigated, the effect on predicted stability also had to be studied. Because the actual vertical center of gravity of the first hull could not be measured accurately, a range was estimated and used for a revised prediction of the Limit of Positive Stability (LPS). The revised estimate of the LPS ranged from a low of about 118 degrees to a maximum of

123. Recognizing that a reduction in LPS is common in boat construction, and that other structural components were yet to be built and weighed, the possibility that the LPS could fall to as low as 115 degrees triggered the Academy's call for revising the keel to meet the targeted LPS safety standard of 125 degrees. Recognizing that a manufacturing cost penalty would be incurred, the Academy authorized Pedrick Yacht Designs for a new keel design that would simultaneously restore the LPS to 125 degrees and reduce the casting weight by approximately the amount that the hull was overweight.

By increasing the draft slightly, adding deadwood below the sump, and being more aggressive with the bulbousness of the keel shape, the designers were able to save most of the structural weight increase from the original design and still increase the stability back to the original targets. Below are the stability curves at mid-construction of the first boat and at launching, showing an LPS of 121 and 125 degrees. The Navy 44 STC Mk II has an IMS Stability Index of 134, 19 degrees greater than the minimum requirement for Cat 1 races in which the yacht will compete, and 14 degrees greater than the minimum for Cat 0 races.

The added construction cost per boat of the change was approximately $30K, which included scrapping the original keel mold and the first five keels.

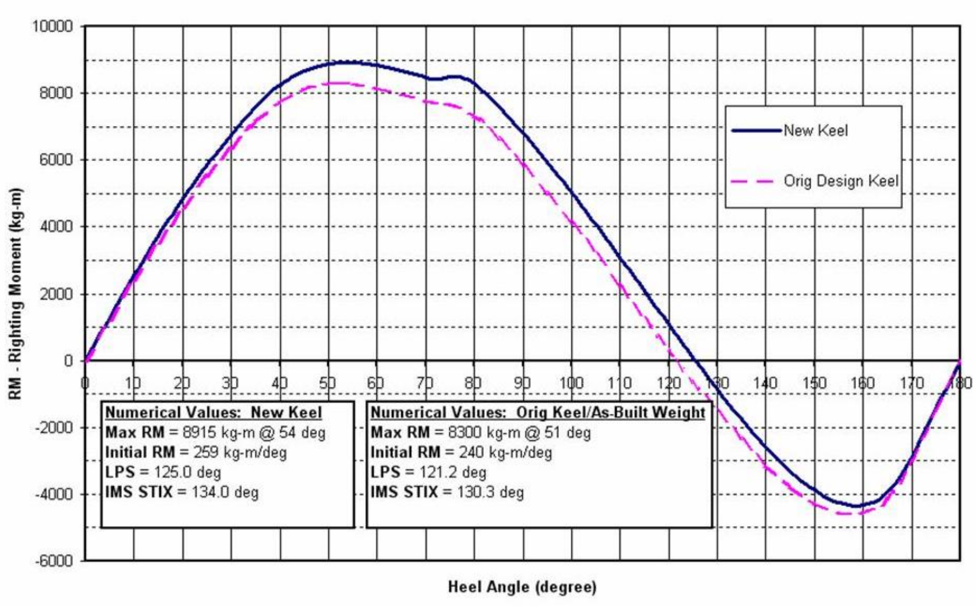

Figure 13: Stability Curves before and after keel mod

Performance

Figure 14 shows the predicted polars for the NA44 MK II compared to the polars for the existing MK I's at 6, 10, and 16 kts true wind speed. Actual sailing experience of the MK II's against the MK I's suggests that the performance increase has been even greater, particularly in higher winds. The boats have even hit sustained speeds of 16 knots (peak 17.8) while reaching in a 50 knot squall in Chesapeake Bay.

As the primary task of the vessel is sail training and not racing, optimization of design to rating rules was given low priority. At the time of the design, IMS was still the commonly used rating rule in the US, and the MK II design was expected to be rated reasonably. However, by the time the first hull was completed, IRC, which originated in Europe, had become the predominant rating rule in the U.S. The NA44's are now racing under IRC and U.S. Sailing's Offshore Rating Rule (ORR). ORR is a VPP based rating rule developed as the successor to Americap II. The Americap rule, in turn, had been based largely on the IMS VPP.

Under ORR, the NA44 STC Mk II has a General Purpose Handicap (GPH) of 619.3, which is in the same range as Frers 41's, Express 37's, and Swan 46's. The IRC rating is 1.071, putting it in the same range as First 40.7's, Swan 44 Mk2's, and C&C 115's.

Unfortunately, while the MK II has wholesome design features that would be treated reasonably under the IMS, some of these are penalized by the IRC. One is the heavy-duty, double-lower, inline-spreader rig with heavy-weather running backstays to support a forestaysail in storm conditions; the IRC treats it similarly to an aggressive, highly tunable, inline spreader rig with checkstays. Also treated unfavorably by IRC is the masthead genoa and large foretriangle area, penalizing considerations of the offshore ability of this configuration. Additionally, the keel, although conservatively sized and moderate in its bulbousness, is counted as a higher-performance, low VCG type.

CONSTRUCTION

TPI (later Pearson Yachts) won the bidding process to build the 24 boats. The specification was somewhat

flexible in the construction process, allowing for hand layup, resin infusion or wet preg (pre-impregnation). Pearson was a leader in the SCRIMP resin infusion process, which offers the potential benefits of greater laminate compaction, reduced void content and reduced resin content.

The hull was constructed in a three-part female mold that was split down the centerline and included the transom/life raft locker as a separate mold. Figure 15 shows the hull grid during installation. All structural components were installed prior to removing the hull from the mold.

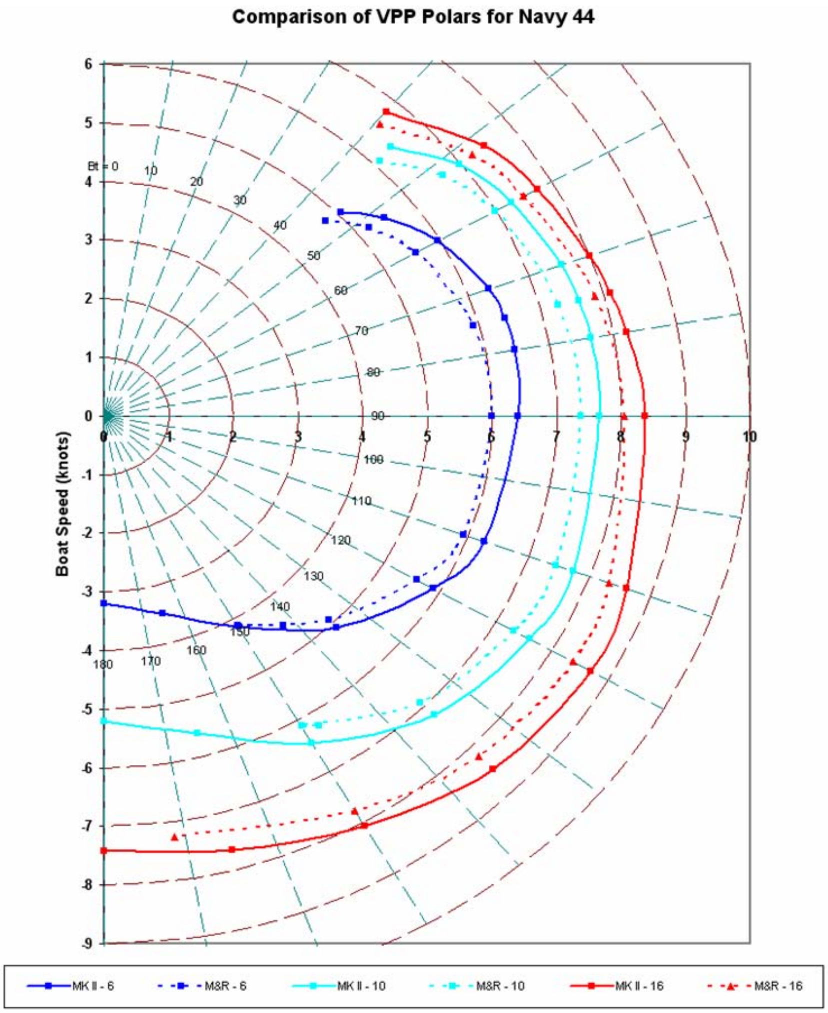

Figure 14: Predicted polars for M&R and PYD Navy 44s

The deck was laminated on a single-part female mold that included plinths for winches, the binnacle, jib tracks and cleats, as well as dorade vent boxes. All structural bulkheads were composite and bonded directly to the hull. Except in the head, no liners were used. As noted above, the core was replaced with solid laminate or G-10 in all high load areas or through-hulls.

Construction of the new boat progressed more slowly than many anticipated. In addition to the delay from the keel change noted above, several other significant issues slowed construction. The first was the inability of the builder to meet the specified laminate quality requirements on resin content and void limits. This was due in part to the builder's unfamiliarity with the resin system, and then by long delays at the testing lab. The builder brought in a consultant who helped resolve the void content. NAVSEA approved modifications on the limits on resin content, and a more timely testing lab was selected.

The second and third construction delays were caused by design details for which the builder requested additional work by the naval architects. Government contracting practices led to a longer time to resolve the difficulty. Two unusual features of the deck detailing were the sliding foredeck hatch and the transom storage locker for the life raft. These were shown on the bid drawings without issue when the builder submitted its bid. However, during construction, the builder complained incorrectly that the designs could not be built. NAVSEA held the builder responsible, since the basic designs were included in the bid plans. Pedrick Yacht Designs believed that the provided level of detail matched the agreed-on scope of work, with the builder accountable for providing the necessary details for construction. However, the builder had significantly reduced the size of its engineering staff and was unable to do the work. Because the designer was not funded for continued design work during construction, the Academy found additional funding so that Pedrick Yacht Designs could support the builder with details for these hatches' construction. Delay-causing situations such as these illustrate the value of keeping the principal designers involved throughout the production cycle to help expedite snags that are, to some degree, unavoidable in any project.

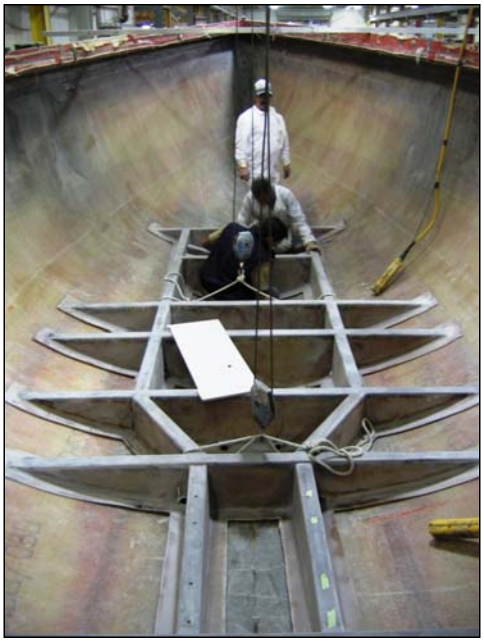

Figure 15: Floor grid installation

Quality Control/Quality Assurance

The Navy 44 MK I's had been constructed with significant voids along the stem and at the lower rudder bearing. As these areas were concealed with blue gelcoat, they were difficult to inspect during construction. Following recent Navy practices, the laminates for the new 44's were specified with clear gelcoat to facilitate inspection. An exception was made for one face of the bulkheads to be gel-coated for a good surface finish, deeming it sufficient to inspect one side for major flaws. The upper side of the deck laminate was also given a waiver on the clear gelcoat requirement due to the impracticality of painting around the Treadmaster.

After the builder proved its ability to laminate within the specified limits, various methods were employed to check laminate quality throughout the build process. The first was a visual inspection of each part with an acceptance criterion described for each type of flaw. The second was a test laminate for each hull to verify material properties based on the actual resin, cloth and core used. The third method was to test a representative sample of cutouts for void and resin content.

Each system component and design feature was tested for compliance with the specifications. This arduous task was handled jointly by the Defense Contract Management Agency's (DCMA) Boston Office and the Naval Surface Warfare Center's Combatant Craft Department.

Change Orders

All construction projects generate change orders during work in progress, and the longer the project lasts the more the change orders. This is inevitable due to the changing of equipment availability and unforeseen issues. For a boat building contract spanning multiple years the anticipated costs of the change orders are 10-15% of the contract price. At the time the first boat arrived at the Naval Academy the 74 change orders represented 11.5% of the original contract price. The largest single cost was for the keel modification (52% of the total cost of all change orders). More than half of the change orders were for replacements of items no longer available. Another third were for no-cost changes related to construction detailing and methods.

A separate issue was the calculation of delay and disruption charges. Whenever the contractor waits for a government decision the contractor is able to charge for the delay, much the way a taxi charges for waiting. Compounding this is that any change cannot progress until the government allocates the funds for the change. This highlighted the problem of using ESE funding for the Navy 44. The ESE allocation at the Naval Academy is relatively small and was unable to absorb the design changes. In some cases the funding was not available until the next fiscal year, essentially stopping production. For example, while the technical solution for the stability issue was resolved in six weeks, the funding was not allocated for seven additional months. This resulted in delay and disruption charges roughly four times the technical cost. Total charges related to delays in the allocation of funds totaled nearly a third of the original contract price.

TRIALS AND USE

The sea trials were held off Newport, Rhode Island in September 2007. They included comprehensive tests of every system and an overnight sail. As an illustration of the comprehensiveness, The Trials Agenda was 114 pages (Pearson, 2007). The two most dramatic tests were the liferaft deployment and the steering gear trial. For the liferaft deployment the test simply timed the amount of time it took to deploy and inflate the 10-man liferaft from the stern locker.

The test consisted of unlocking and discarding the transom locker cover, unlatching the liferaft securing hook, pushing the liferaft out of the locker and pulling on the tether to inflate the raft. After all the design and fabrication trials it was a relief to find that the total time to deploy the raft was actually less than six seconds!

Many predicted the boat would not pass the steering gear test due to its extreme loading. Experience with midshipmen indicated that occasionally the boat was

backed down too fast and the helm accidentally released. To simulate this condition "The STC shall be powered astern in a straight-line course to achieve four knots. The helm shall be released and allowed to contact the rudder stops. This test shall be repeated three times per rudder stop." Those familiar with this situation will recognize the potentially large force developed from the helm going hard over. To reduce the shock load the steering system included rubber snubbers. After the test the primary discrepancy noted was that the cables had loosened.

To really see how the boat worked a 24-hour sail was required in the contract with a stipulation that the wind had to exceed 10 knots during at least part of the test. The weather for the overnighter turned out to be a quite pleasant, 4-20 knots with waves up to two feet. This did not push the boat very hard, apart from a tight reach under spinnaker on the way in.

A more intensive test occurred during the delivery home when the boat beat down the Jersey coast in to a 30 knot breeze with a significant wave height of four feet. This provided a more rigorous test of the systems and the watertight integrity. One fastener leaked, and many questioned the decision to move the head forward of the mast!

One week after the first boat arrived at the Academy it participated in the IMS East Coast Championships. Unfortunately there was no time to tune the rig. Nonetheless the new boat led the older Navy 44s around each mark in the series and often finished up to 20 minutes ahead in elapsed time. Subsequently the boats have entered IRC and PHRF races. As noted above, the STCs, while wholesome, do not rate favorably under the type-forming IRC rule and with the old-age allowance advantage for the earlier boats, the Mk 2 Navy 44's are not competitive under IRC. They are however competitive in PHRF and ORR/IMS races.

While increased performance was nice, the bigger question was how it would handle training cruises. The first big test came during spring training in 2008. A common training cruise is to circle the Delmarva Peninsula. This three to four day cruise exposes the crew to various weather, navigation and traffic situations. During an early May trip the crews were caught by a rapidly developing front that produced 35 knot winds with gusts to 50. Consistent boat speeds in the mid-teens were recorded. Feedback was that the boats were dry, strong and easy to handle, but that the bilge pump system needed refinement and much of the standard, off-the-shelf hardware used on recreational boats and the STCs was insufficiently durable for the STCs (Mumper, 2007). During that trip a boat donated to the Academy lost its rig.

A final test of the new boats came in October when Integrity (Mk 2) was hit by Flirt (Mk 1). Each boat was broad reaching on starboard at 6-8 knots when Flirt decided to duck behind Integrity. They hit at an impact angle of approximately 30 degrees from perpendicular. After the initial impact Flirt continued to turn toward Integrity sweeping along the side until leaving in opposite directions. In addition to sweeping off the lifeline stanchions on Integrity and the destruction of the bow pulpit on Flirt, the impact just forward of the rub rail on Integrity resulted in a damage to the laminate approximately 5" wide and two feet long. The damage did not penetrate the hull however and was easily repaired.

Experience to-date has also shown two other design aspects. The spade rudder on the new boat has significantly improved the boats' maneuverability, allowing the midshipmen to more easily avoid dangerous situations. The initial rudder balance of 15% area forward of the rotation axis was well liked by the experienced sailors, but the inexperienced had difficulty with the light helm feel. Starting with NA-25 (the fifth Mk 2) the shaft was moved forward to achieve a 14% balance. Light air performance compared to the old boat is the new design's only performance vulnerability. Due to the higher wetted surface area from the longer waterline, the old boat appears to have a slight advantage in winds less than four knots.

Names

The Navy 44's have used various schemes centering on the concept of names that reflect desirable junior officer traits. Reflecting the evolutionary change in vocabulary, the list for the fourth generation added and removed names. For example, Dandy and Flirt were retired and Honor, Courage and Commitment were added. The lead boat was named after the Renaissance in Navy Sailing started by VADM Rempt, and the third boat, Defiance, was named after the boat developed in a capstone project by naval architecture midshipmen. That project helped convince VADM Naughton that a new design was a good idea.

CONCLUSIONS

While the path to a new sail training craft for the Naval Academy was long and often frustrating, the final result was a successful design that improved on the three earlier generations. Numerous lessons were learned or reinforced.

Lessons Learned

Design by committee can work and create a great product, but it does take a lot of time, effort and patience to keep focused. The Naval Academy understood this from the beginning and managed the project to a successful conclusion.

There is nothing like decades of experience in prior generation craft, years of planning and countless hours of team input to yield an ultimately superior product for the purpose.

The high level of seakindliness, robustness, safety and ease of maintenance that are prescribed for sail training are also desirable characteristics for personal cruising yachts. A large difference between the two however is the required robustness of a sail training craft. Much of the standard equipment and construction details of recreational craft is not up to the demands of a dedicated training craft.

Detailed design specs require more time up front from the naval architects and do not take best advantage of the builder's skills. "Over the wall engineering" is NAVSEA's traditional approach which leads to multiple change orders. A less-fully-detailed design can benefit from the builder's skills but requires continued involvement of the naval architect..

IRC favors relatively heavy displacement and high stability, which were met, but favors a fractional rig having ~70% Fore-Triangle/Main area and a simple swept-spreader rig. The MK II is masthead, with ~100% FT/Main area and robust staying support that is highly penalized as it is misidentified by the rule.

ACKNOWLEDGMENTS

Numerous people played a significant role in the new Navy 44's, from the midshipmen who researched potential improvements to the mids who never failed to tell us what they thought of the boats and to the dozens of others who provided valuable feedback. Certain people deserve special recognition. Ralph Naranjo, the former Vanderstar Chair of Navy Sailing played a pivotal role. Mr. Karl Kirkman, who headed the M&R Navy 44, started this program and led it during its initial stages.

Tom Carr and Jim Mumper of the Naval Station provided extremely valuable information to ensure a low-maintenance, low life-cycle cost vessel.

Buddy McKinley and Jennifer Burrell of CCD contributed significant inspection and builder interaction services. John Fasteson of DCMA spent more time at the builders inspecting the boats than anyone and may never get all the fiberglass dust off his clothes.

Renee Mehl, who succeeded Ralph as the Vanderstar Chair took over the CCC after the first boat was delivered and spent countless hours ensuring that the initial lessons learned were implemented.

The Navy Sailing staff, including, but not limited to, Dan Rugg, Brad Dellenbaugh, Gerard Vandenburg, Pete Carrico and Peter Sarelas provided valuable feedback during the design development, sea trials, delivery and early racing and training events.

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